Jet tomography of the proton at the EIC

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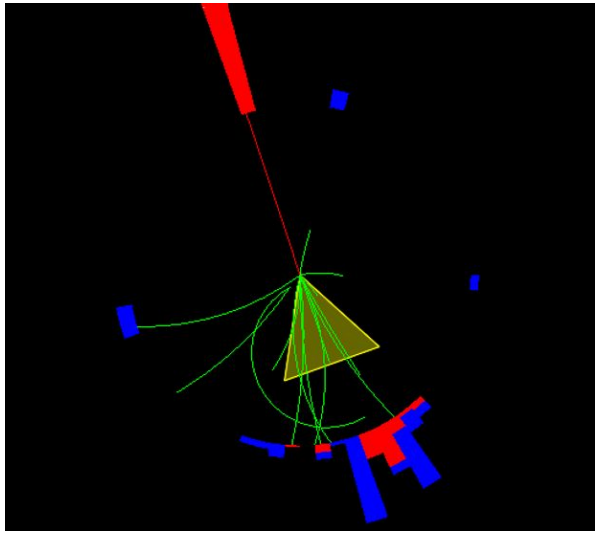
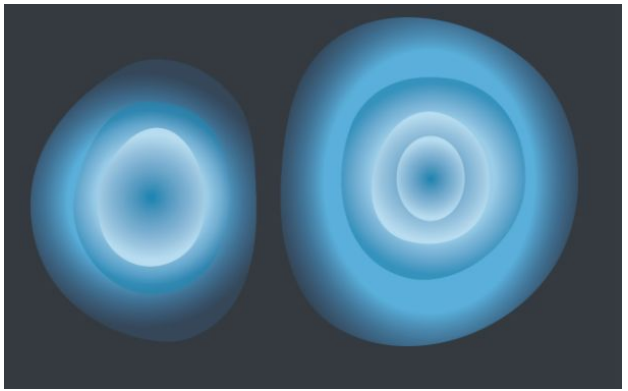
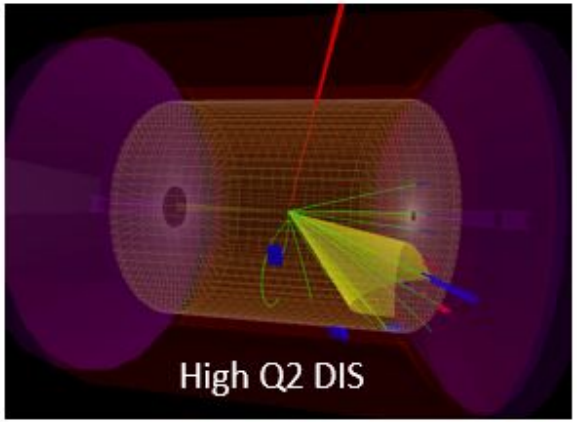
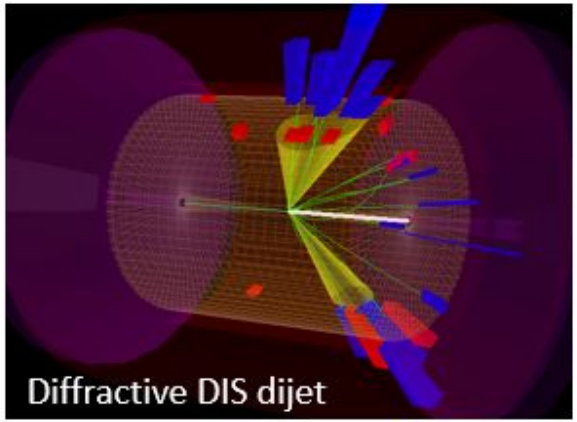
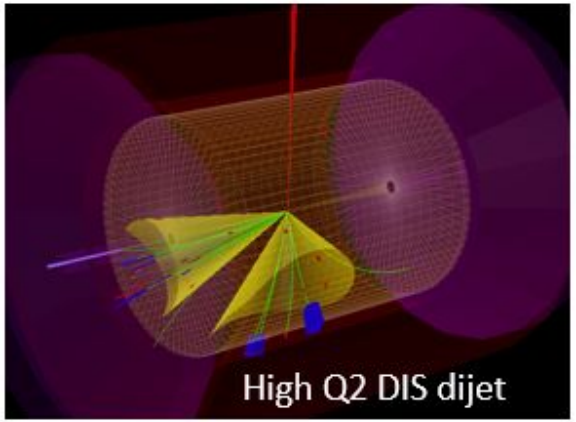


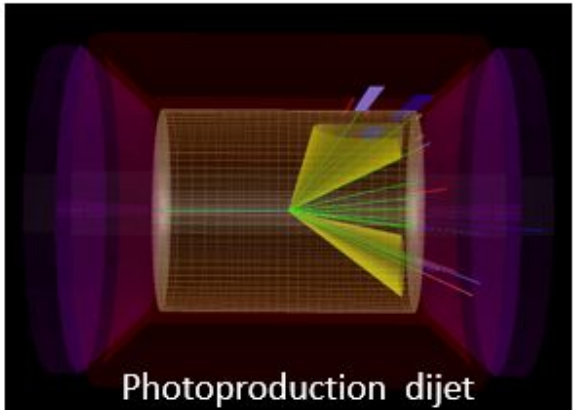


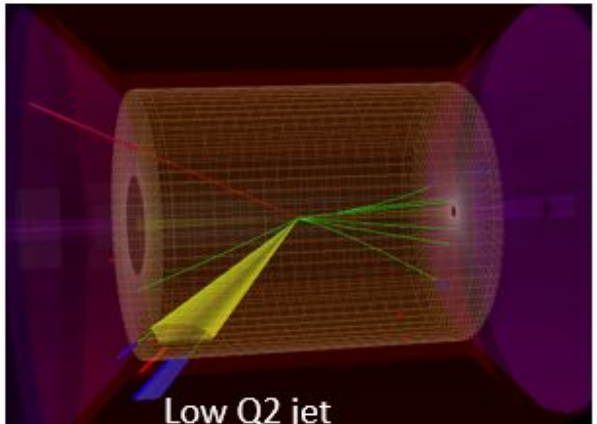
The EIC, a jet factory, will make the first jets in nuclear DIS and proton-polarized DIS

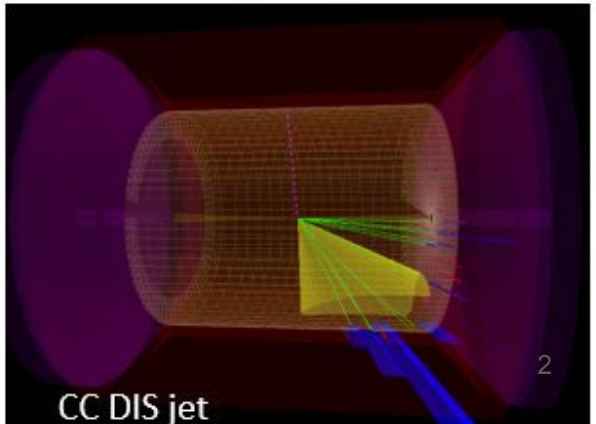






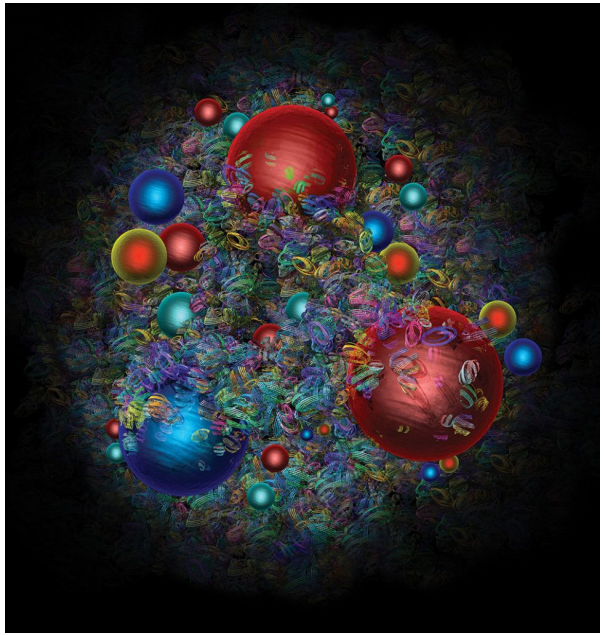


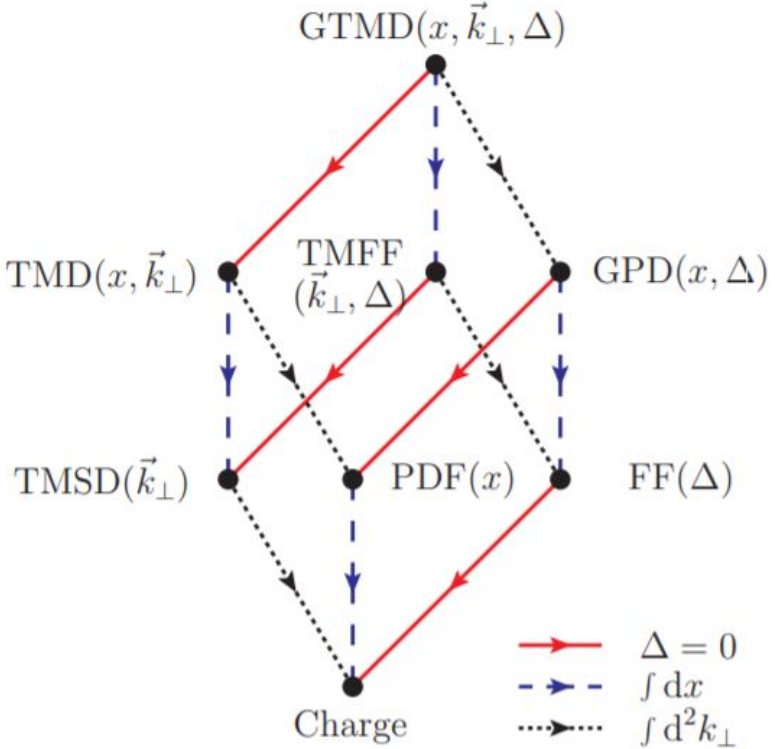




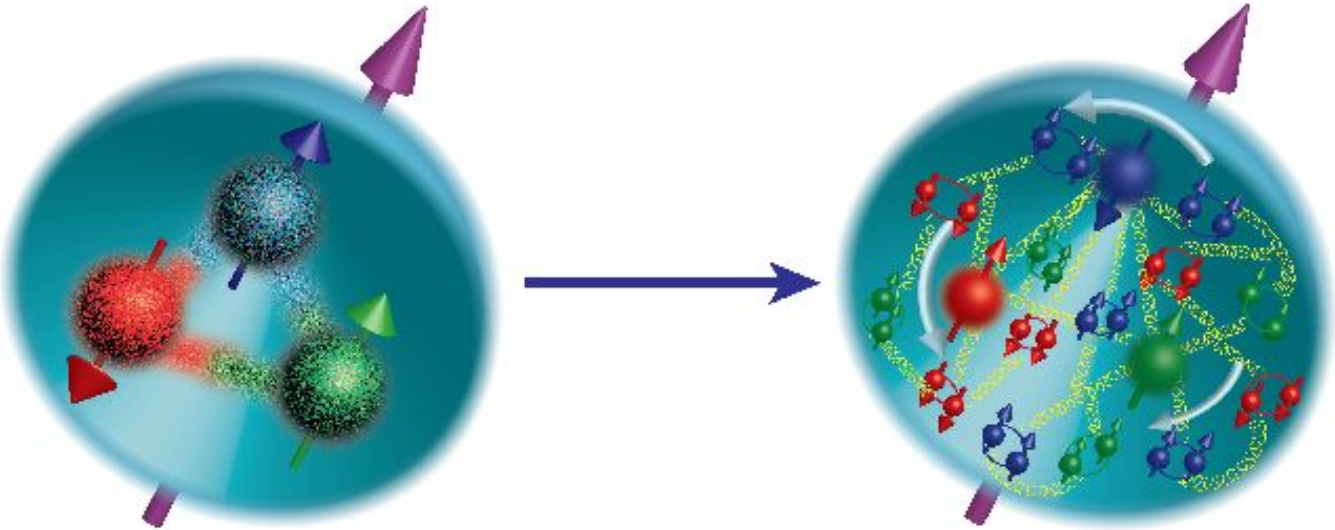
Ideally, a complete "quantum tomography" of the proton involves:

$$W(x,p) = \int \psi^*(x-\eta/2)\psi(x+\eta/2)e^{ip\eta}d\eta \ ,$$





We will probe unexplored aspects of the theory of strong interactions that govern the "evolution" of the 3D structure with energy

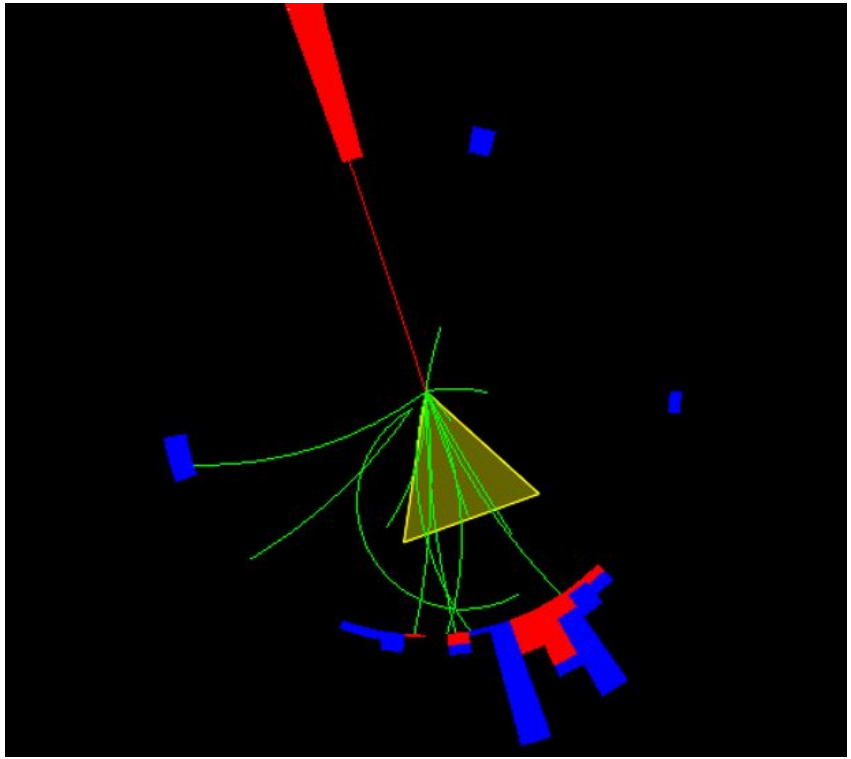


Proton probed at low resolution (low scale)

Proton probed at high resolution (high scale)

A new channel to probe for quark transverse-momentum distributions (TMDs) and evolution

Liu et al. PRL. 122, 192003, Gutierrez et al. PRL. 121, 162001

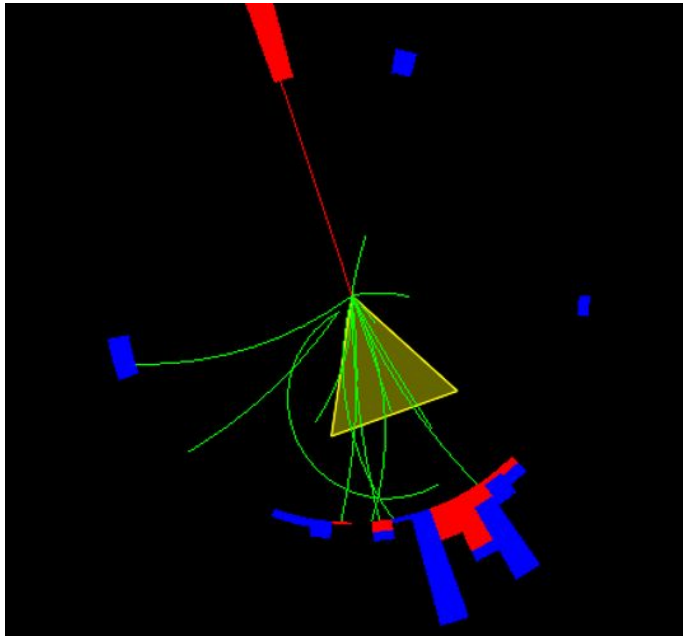


$$\gamma^* q \rightarrow q$$

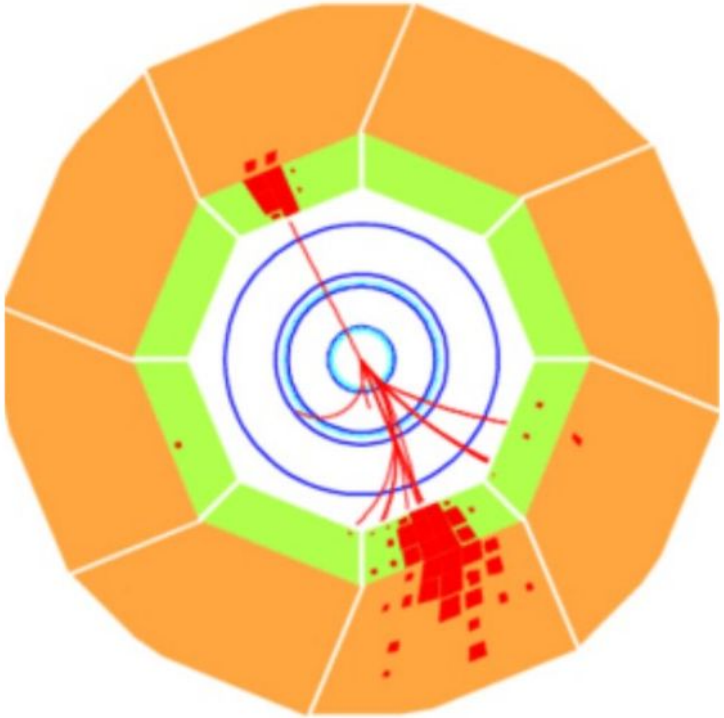
"The advantage of the lepton-jet correlation as compared to the standard SIDIS processes is that it does not involve TMD fragmentation functions."

We can actually explore feasibility of these measurements and test the TMD calculations with the unpolarized data taken at HERA

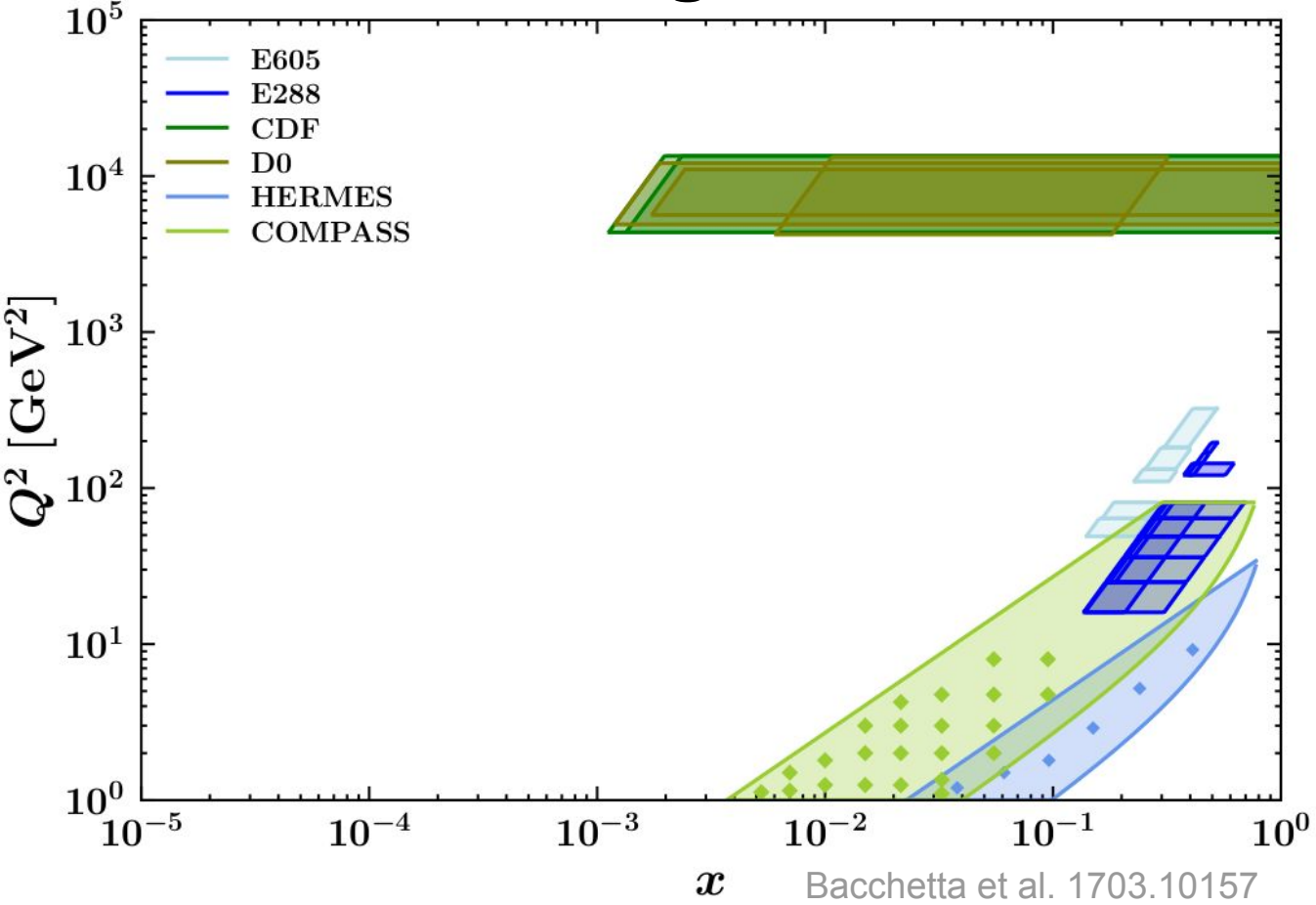
EIC



H1@HERA

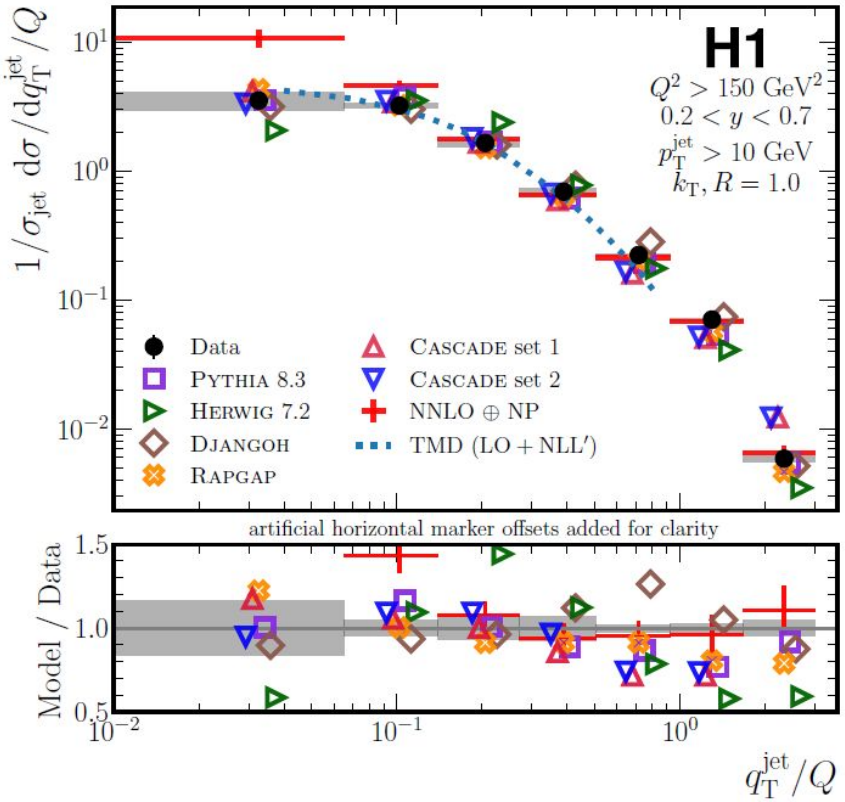


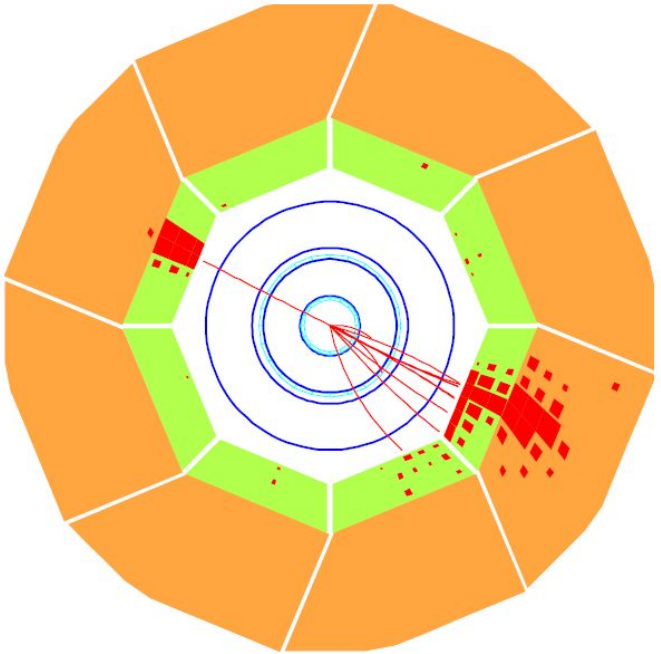
Existing TMD data



Bacchetta et al. 1703.10157

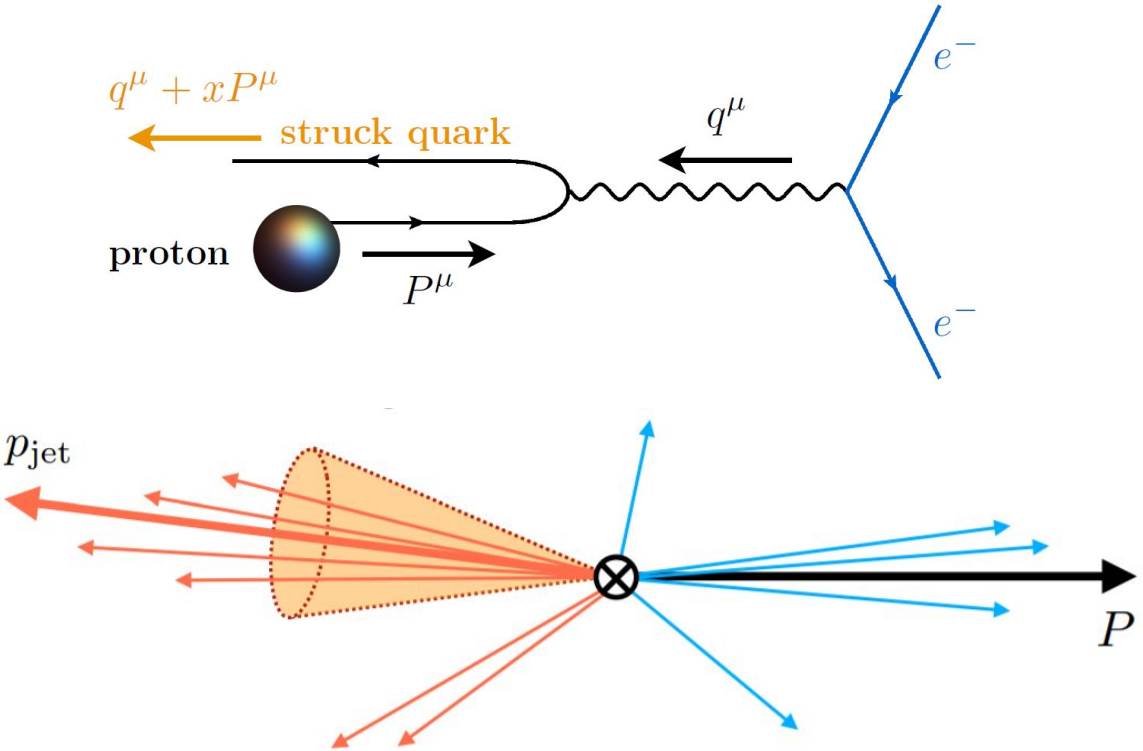
New H1 measurement https://arxiv.org/abs/2108.12376



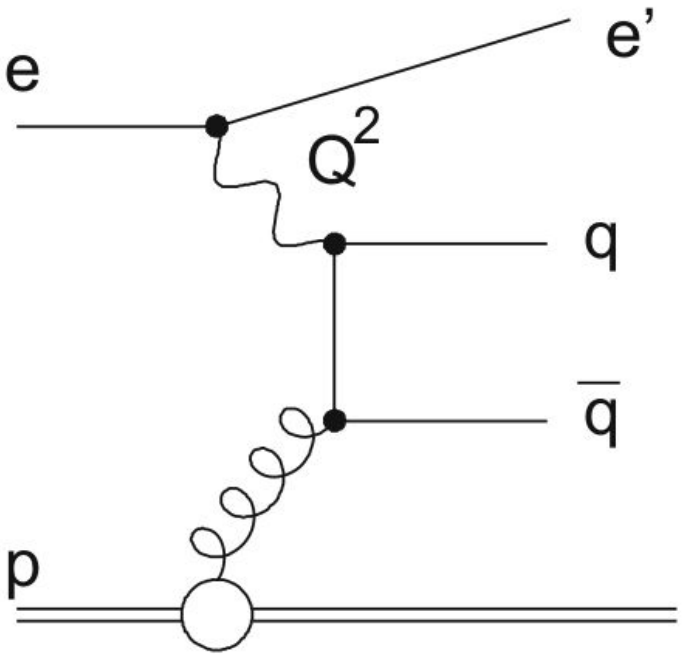


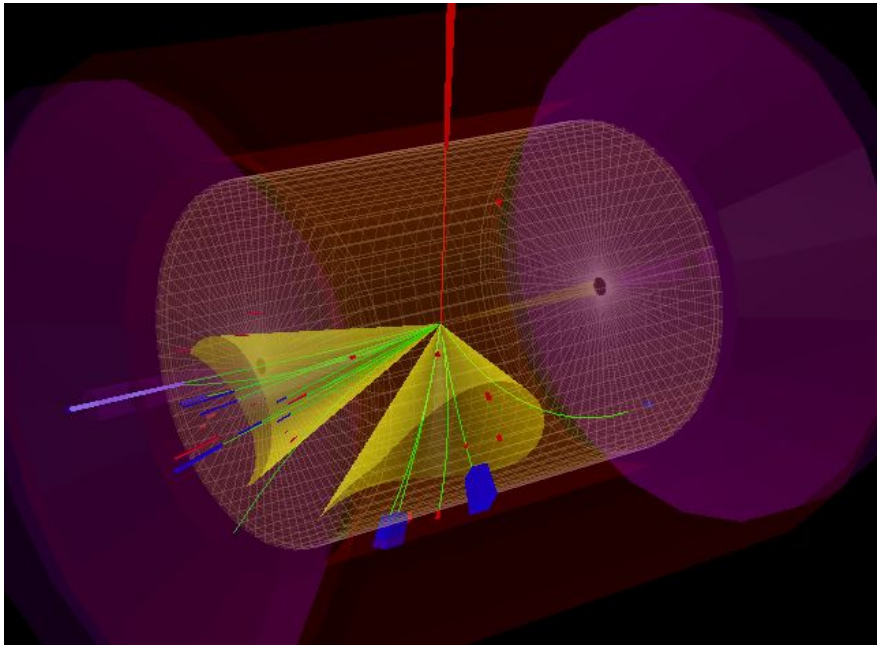
These studies also possible in Breit frame (in complete analogy to SIDIS), but requires dedicated jet algorithms, like Centauro

Phys. Rev. D 104, 034005 (2021)



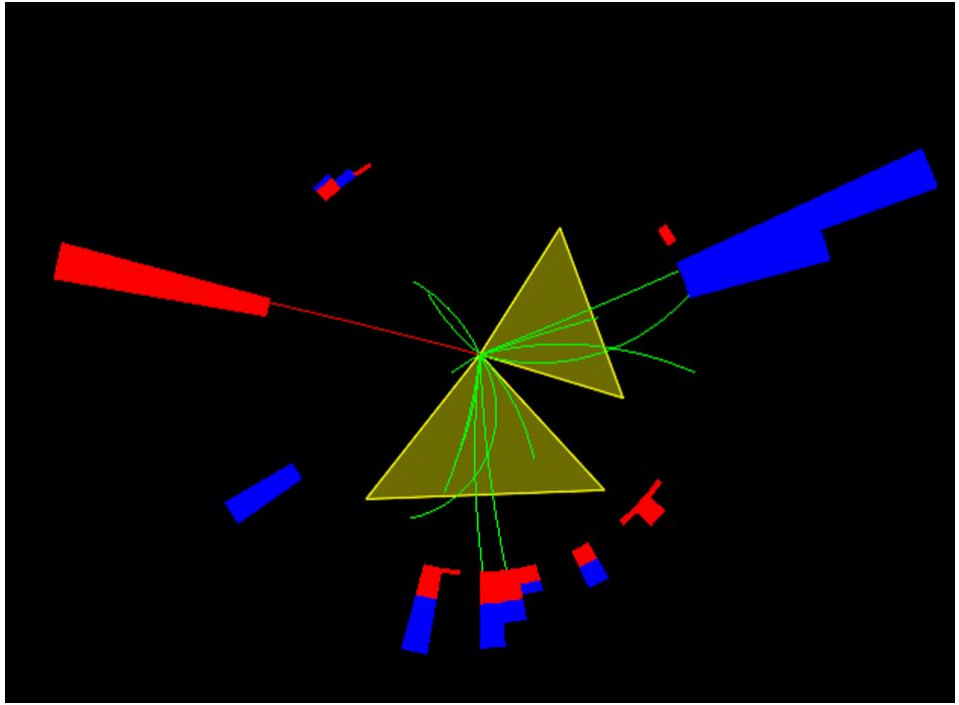
Dijet events probe the gluon TMD distributions

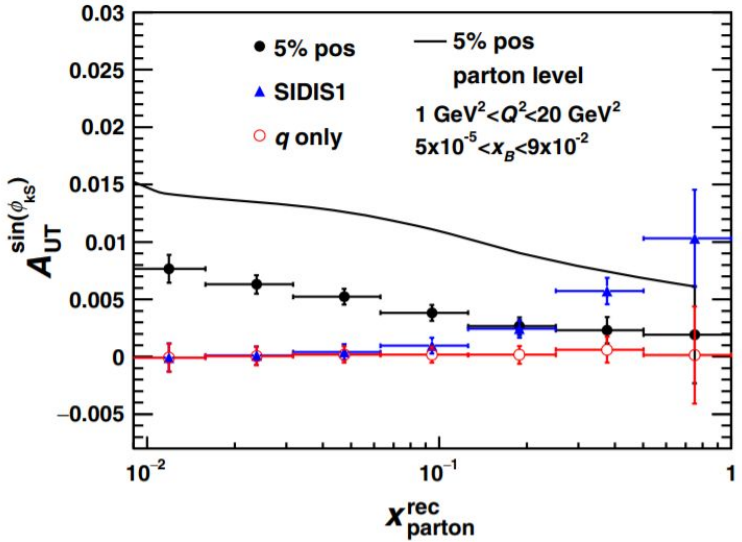




“Di-jet channel is the most promising way to constrain the magnitude of the Gluon Sivers function”

L. Zheng et al. Phys. Rev. D 98, 034011 (2018)





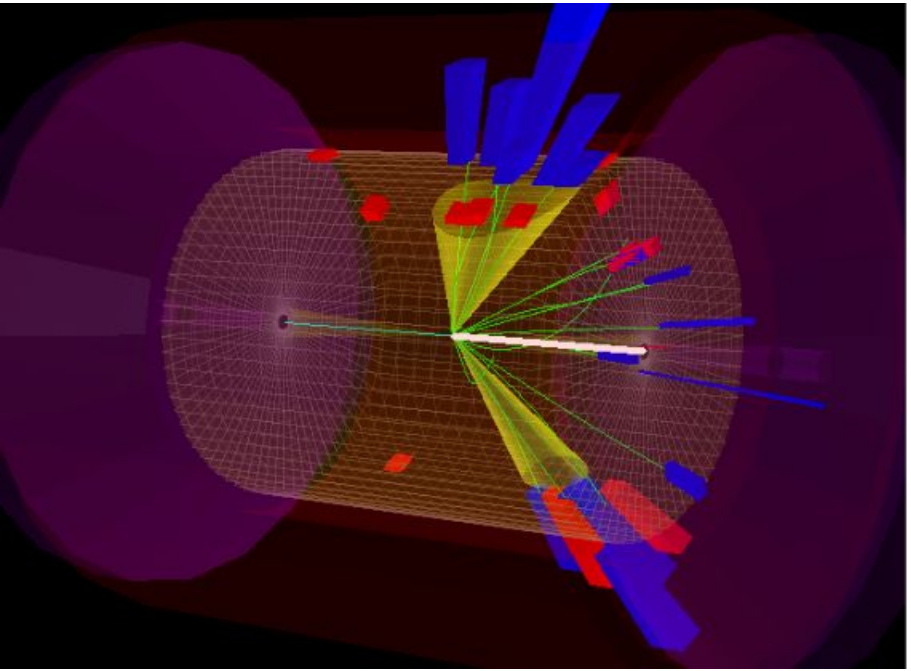
There is a ton of recent work on this topic...

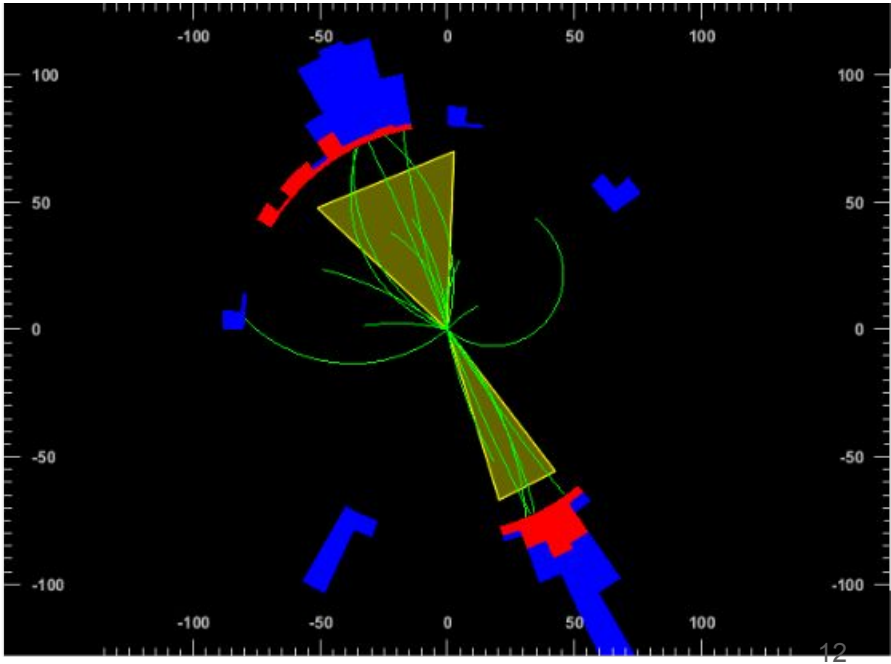
Diffractive jets azimuthal asymmetries probe Wigner function

(Hatta et al. PRL. 116, 202301 (2016))

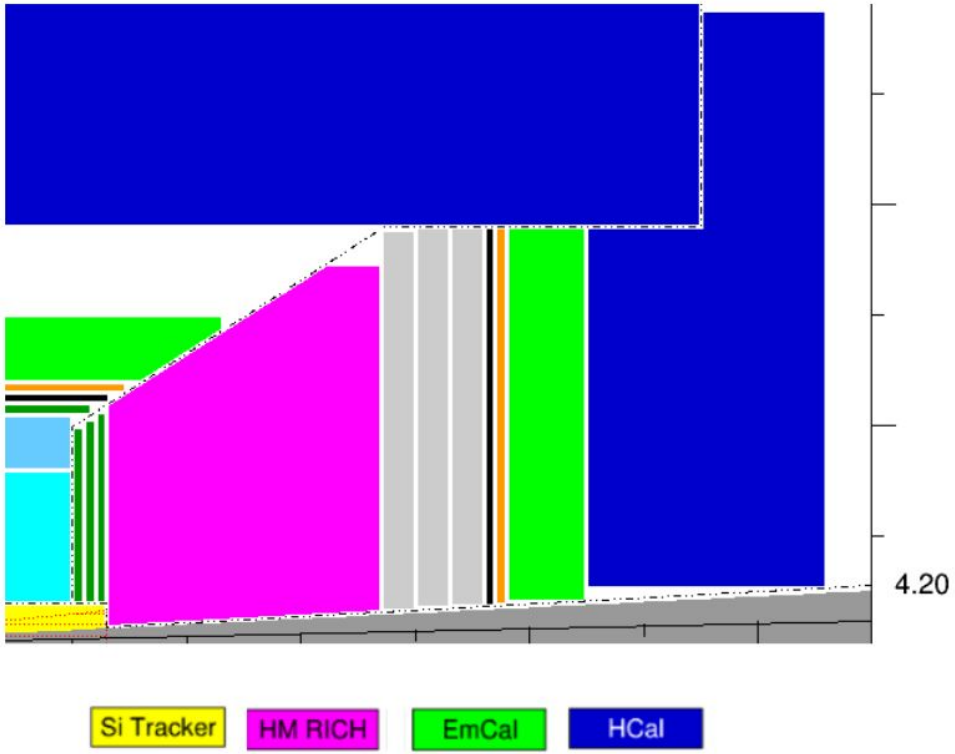
The “holy grail” of 3D imaging studies

$$W(x,p) = \int \psi^*(x-\eta/2)\psi(x+\eta/2)e^{ip\eta}d\eta \ ,$$





Potential for unprecedented jet measurements



Combined with EIC high luminosity and polarization, this combination will enable unique **jet substructure measurements**

Jet substructure, the key to novel TMD studies

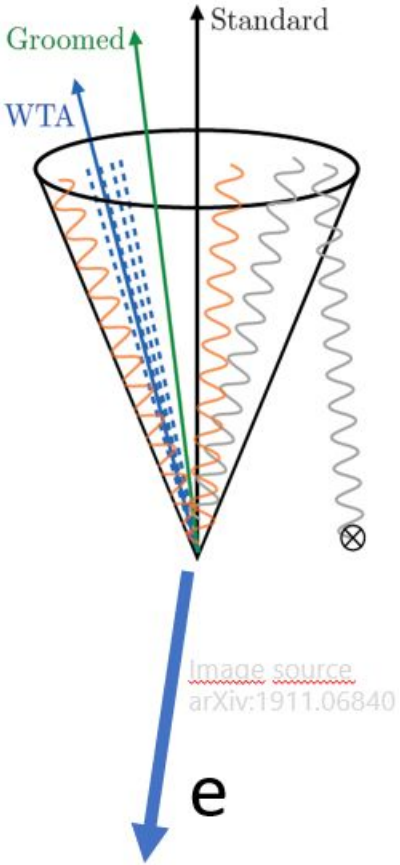


Image source
arXiv:1911.06840

Recent example:
“T-odd jets” (arXiv:2104.03328)

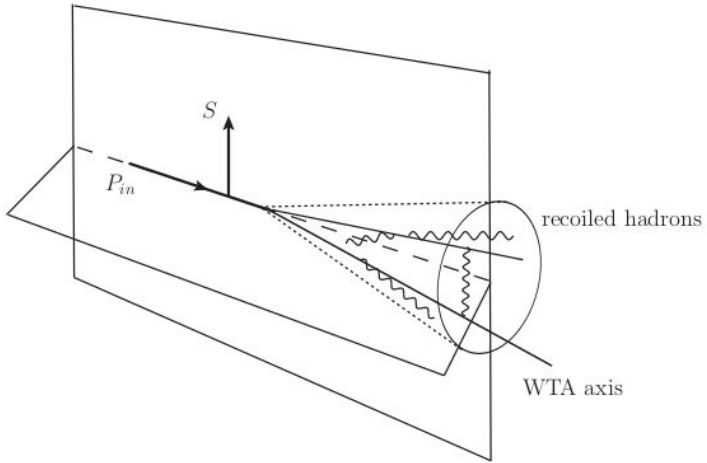


FIG. 1. Origin of the jet T-odd contributions. The WTA jet axis lies outside the plane by the spin S and P_{in}, to allow for the asymmetry due to the quantum correlation between parton's spin and its hadronization about the plane.

- **Grooming**

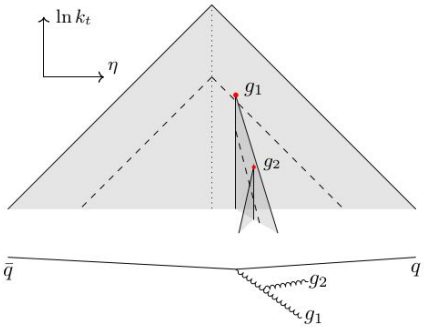
  Gutierrez et al. JHEP 08 (2019) 161 . Makris et al. JHEP 07 (2018) 167

- **Jet axes**

  Cal et al. JHEP 04 (2020) 211, Niell et al. JHEP04 (2017)020 Liu et al. arXiv: 2104.03328

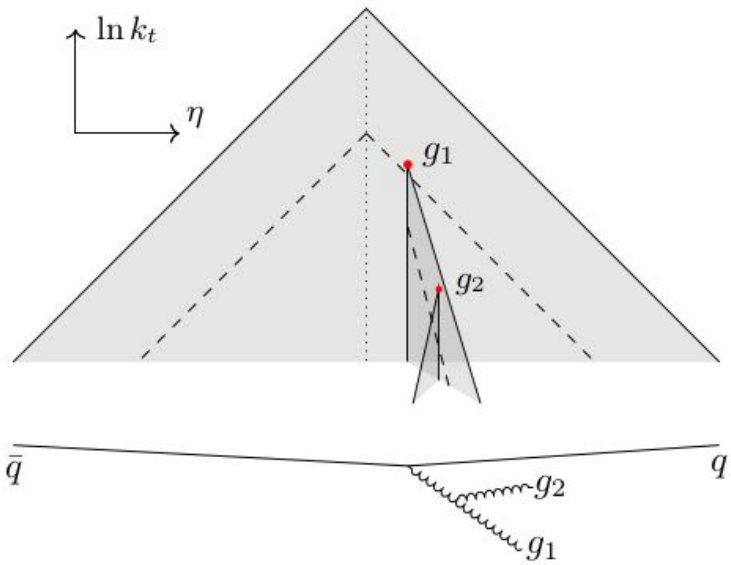
- **Declustering?**

  arXiv:2103.16526

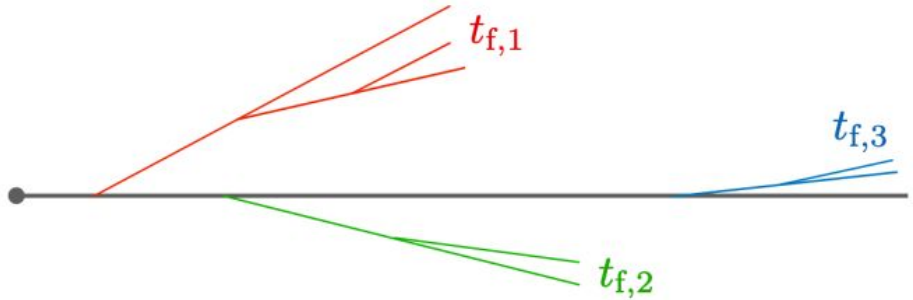


Spin effects in jet fragmentation

Renewed theory thrust, new observables. (Phys. Rev. Lett. 126, 112003 arXiv:2103.16526),



Lund-Plane analysis



Provide ways to explore smoothly transition to non-perturbative regime

Potentially new ways to address EIC science ??

Summary

- Jets can help us address key EIC science goals, including 3D imaging measurements.
- Jet substructure could open up new class of studies.
- EIC jet studies will exploit unprecedented combination of Tracking, PID, full calorimetry and beam polarization.
- The future of jet physics at the EIC is bright.
  Adaptation of LHC/RHIC techniques to EIC ongoing